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Online databases : WPI, INSPEC

(54) Improvements in telecine


(57) To effect digital correction for afterglow or flare in a flying spot telecine, each of a series of stages calculates the contribution to the digital video signal $V_{in}$ at any one scan location (e.g. pixel) which is attributable to afterglow from previously scanned locations or flare from adjacent locations. In each stage the video signal is delayed (10, 12, 14), multiplied (16, 18, 20) by a factor L1- L3 reflecting the flare or afterglow decay characteristics, and subtracted from the undelayed video signal. To reduce the number of stages, the delays may be increased (binary series, figure 3) for signals more remote form the undelayed signal. The factors L1 - L3 are determined in an initial alignment process involving a number of frames and averaging to counter noise errors, and stored in elements 22 - 26; measurement for afterglow is performed on a single bright central pixel, whereas the spatial distribution of flare has to be accounted for by using a bright raster and a test slide with a pixel sized clear spot. Flare correction may involve a single scanning line, or a block of pixels on adjacent lines about the pixel. Fig 4 illustrates a solution to the requirement that black level clamping must precede A/D conversion but follow afterglow or flare correction.

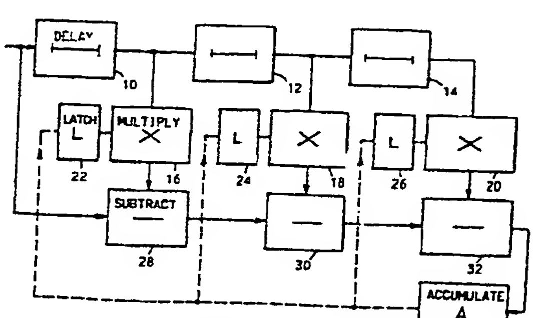




FIG.2

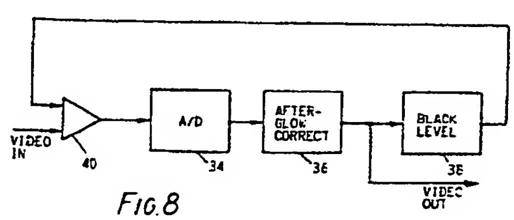



FIG.8

GB 2 239 572 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

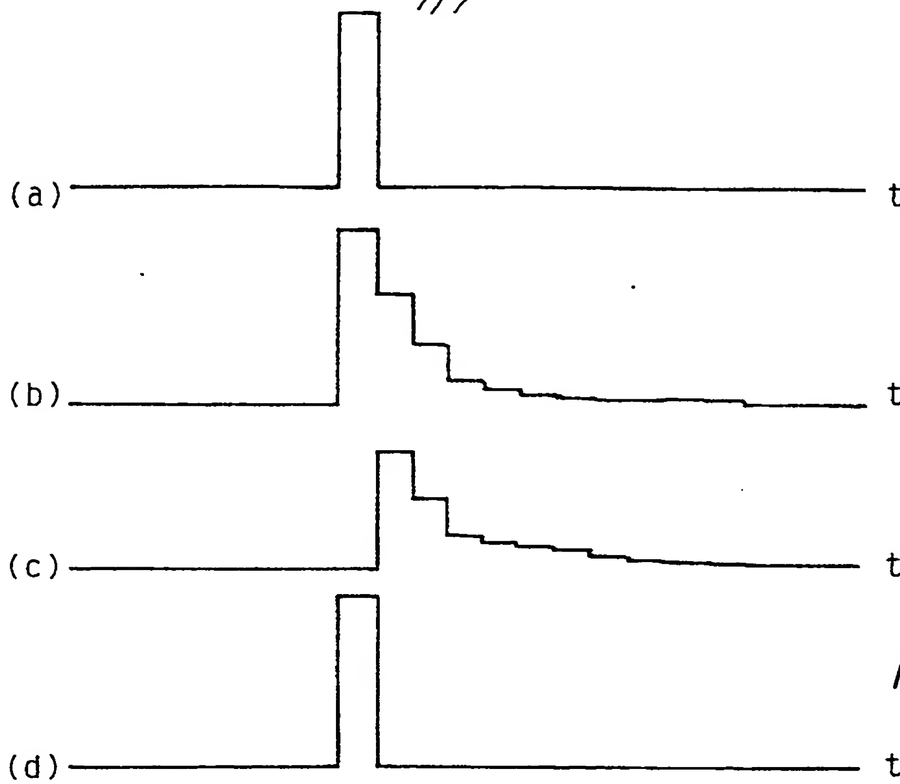

(a)
t
(b)
t
(c)
t
(d)
t

FIG. 1

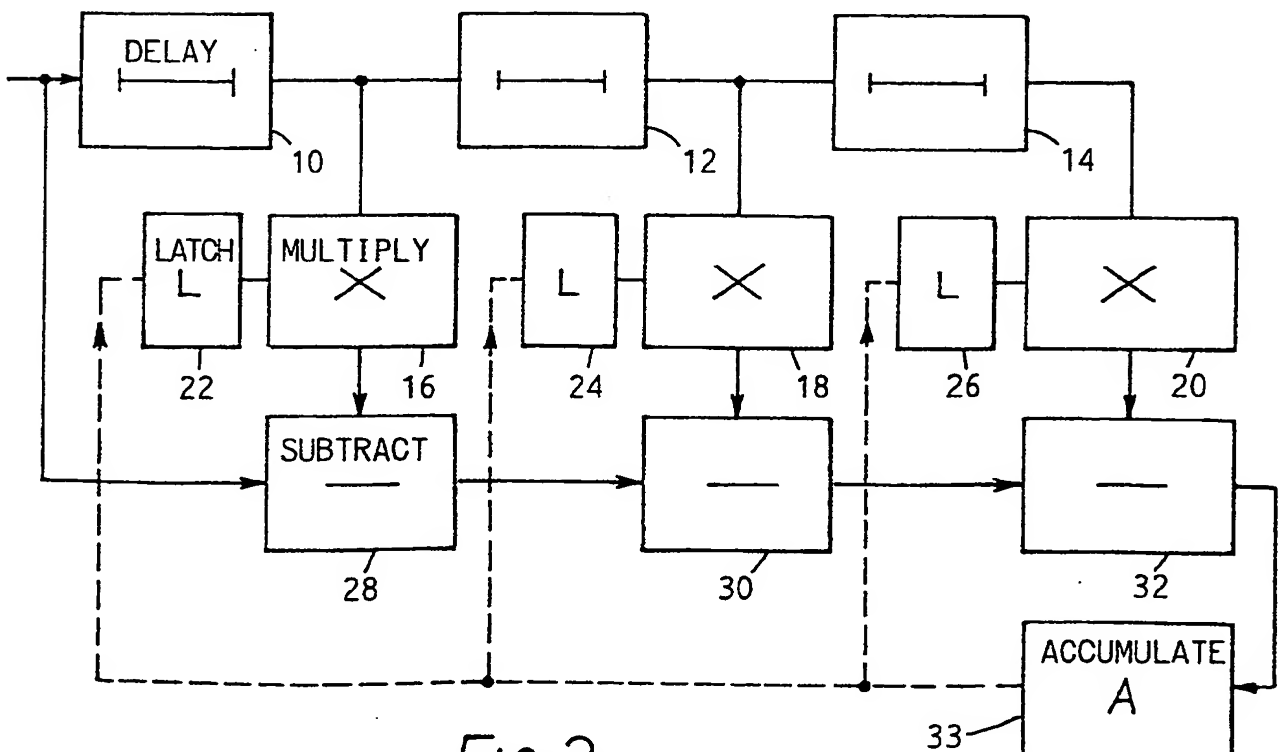

DELAY
10
12
14
LATCH
L
MULTIPLY
L
L
22
16
24
18
26
20
SUBTRACT
28
30
32
ACCUMULATE
A
33

FIG. 2

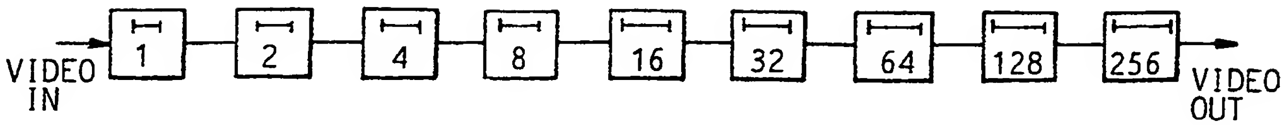



FIG.3

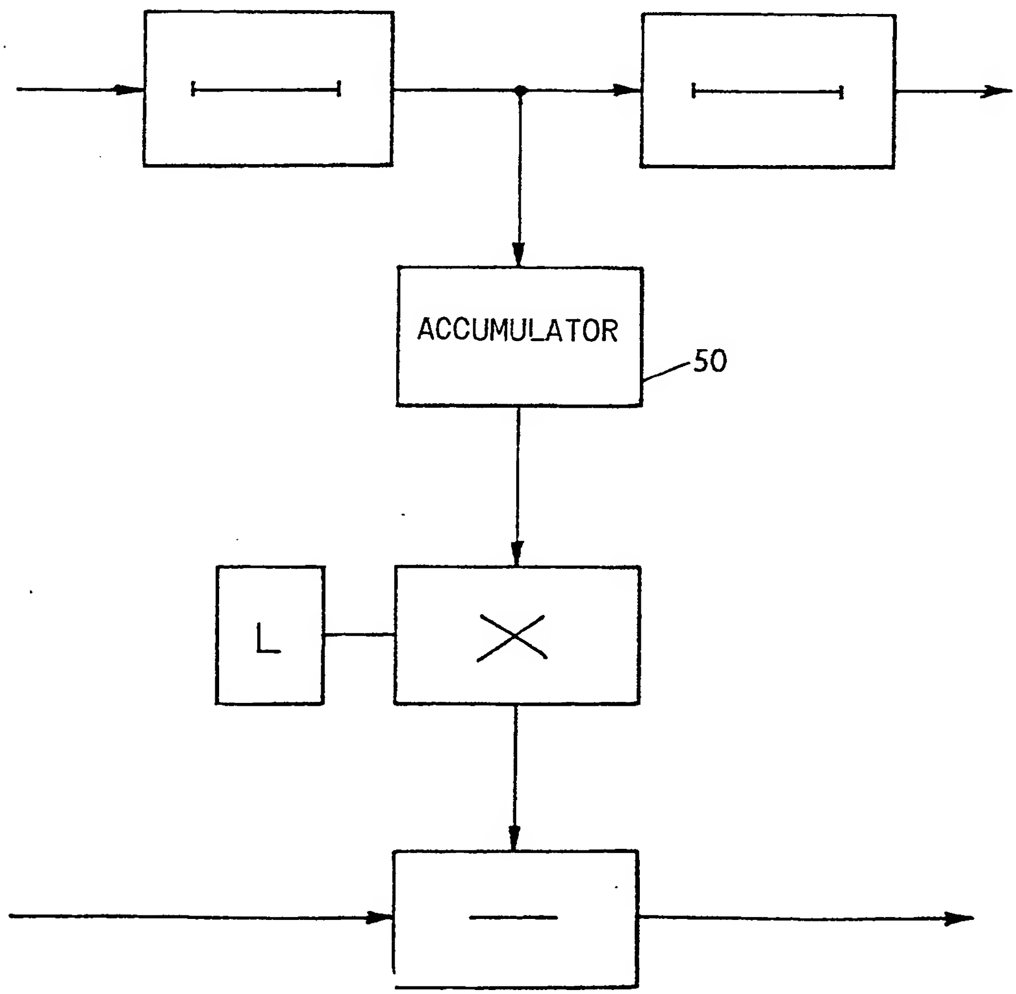
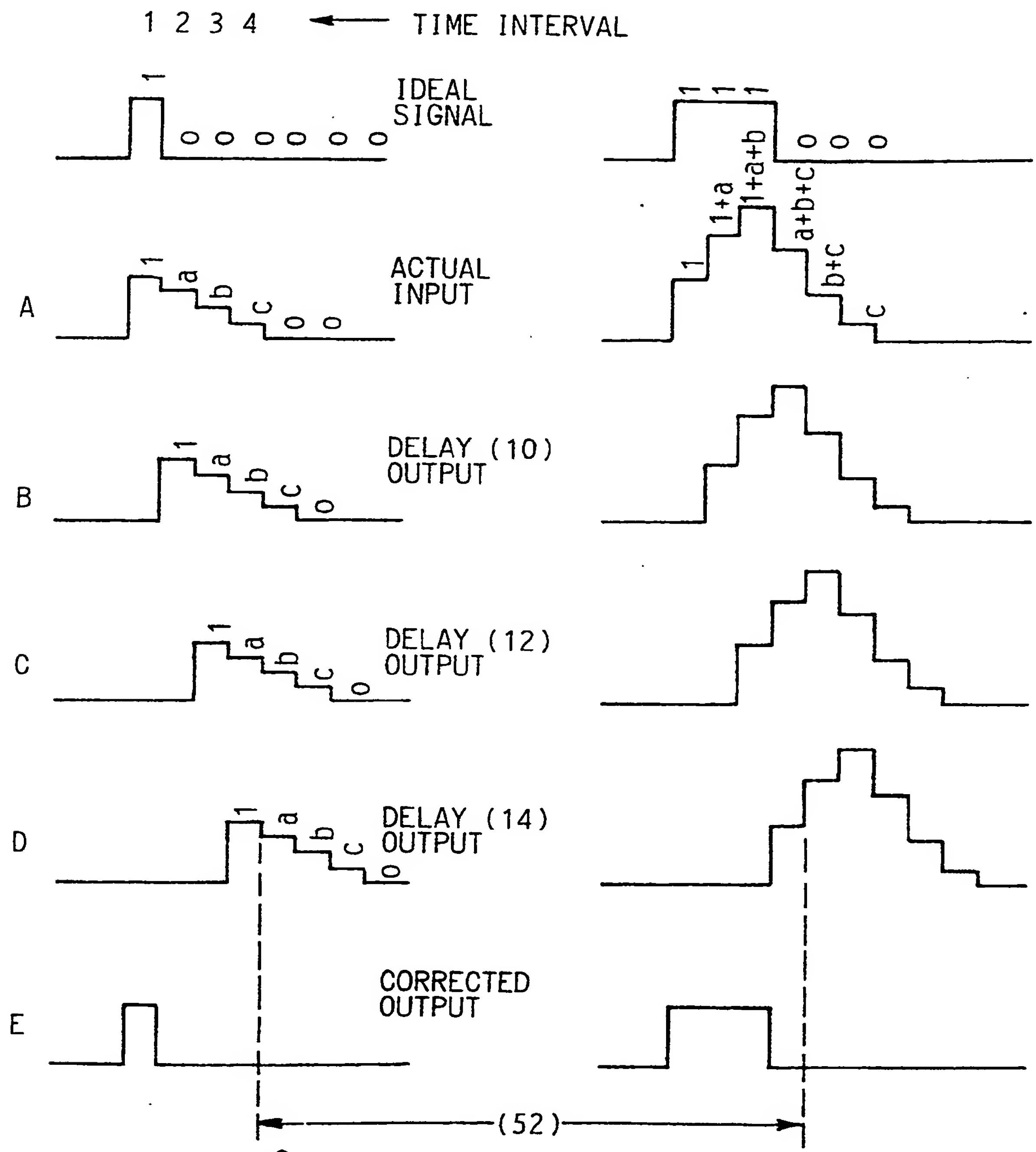



FIG.4




$E = A-B(a)-C(b-a^2)-D(c-2ab+a^3)$

FIG.5

FIG.6

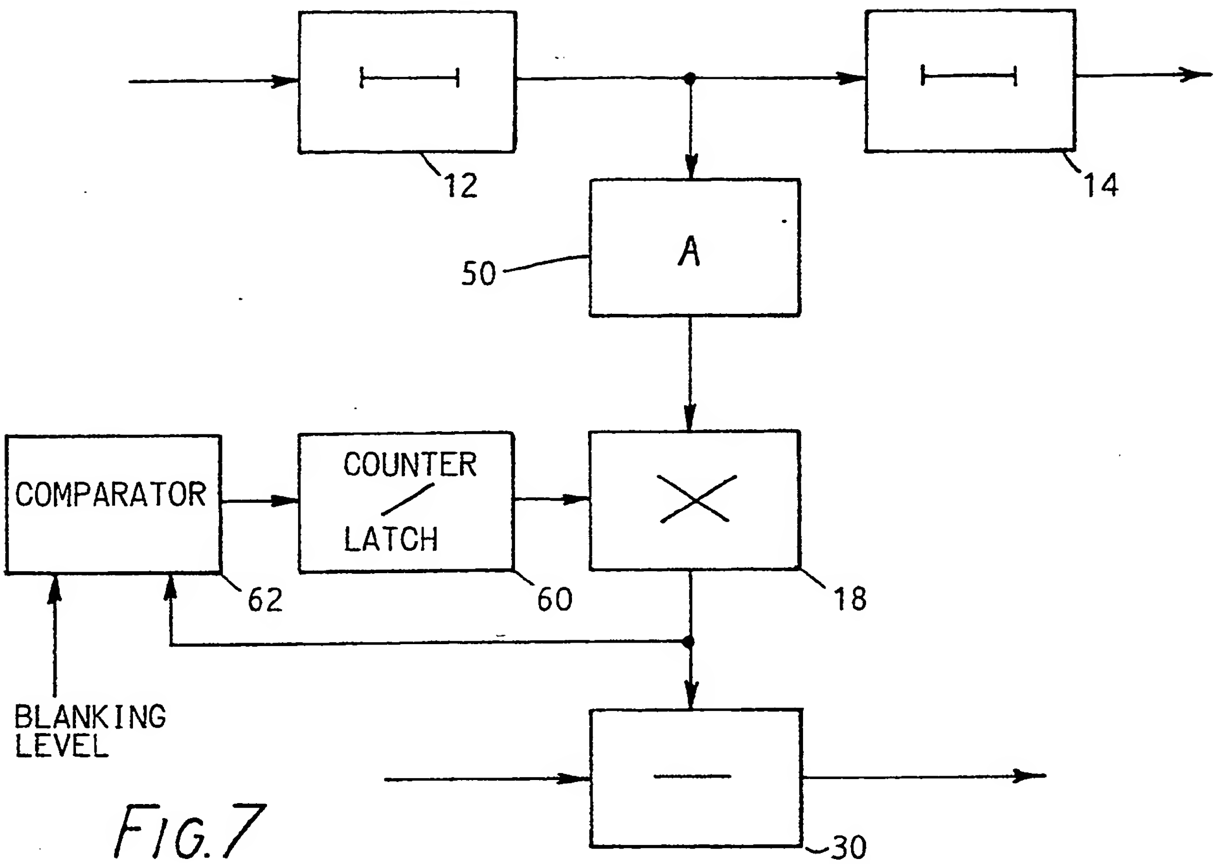

12
14
50
A
COMPARATOR
COUNTER
LATCH
62
60
18
BLANKING
LEVEL
30

FIG. 7

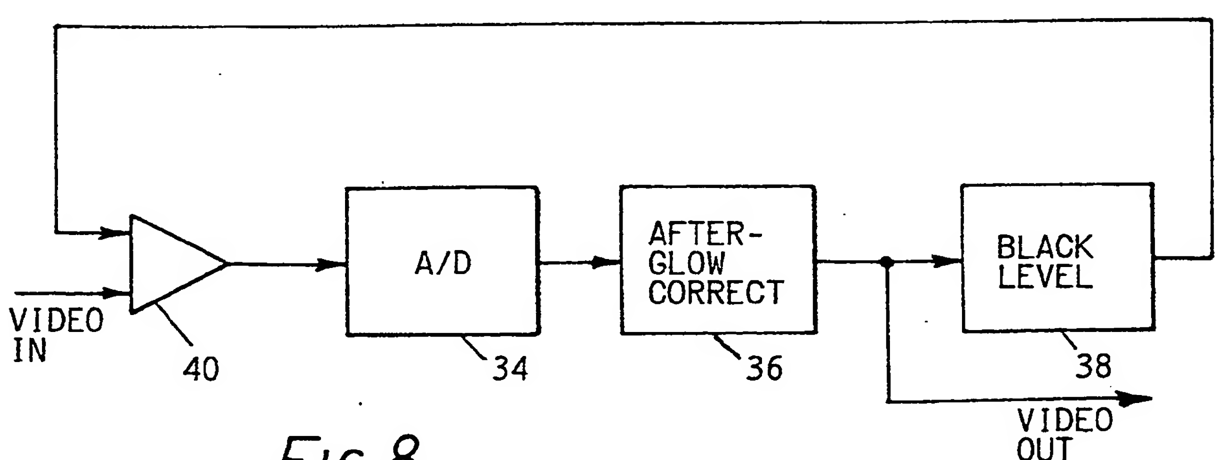

VIDEO
IN
40
A/D
34
AFTER-
GLOW
CORRECT
36
BLACK
LEVEL
38
VIDEO
OUT

FIG. 8

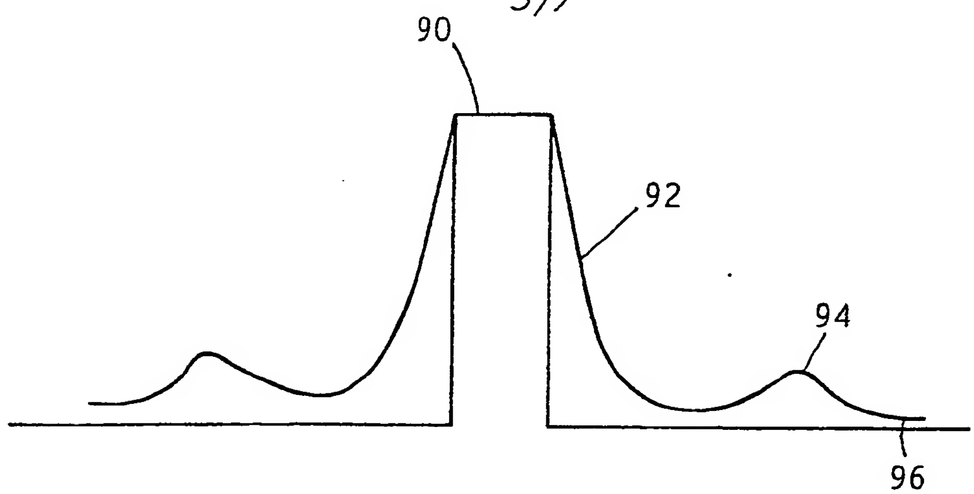

90
92
94
96

FIG. 9

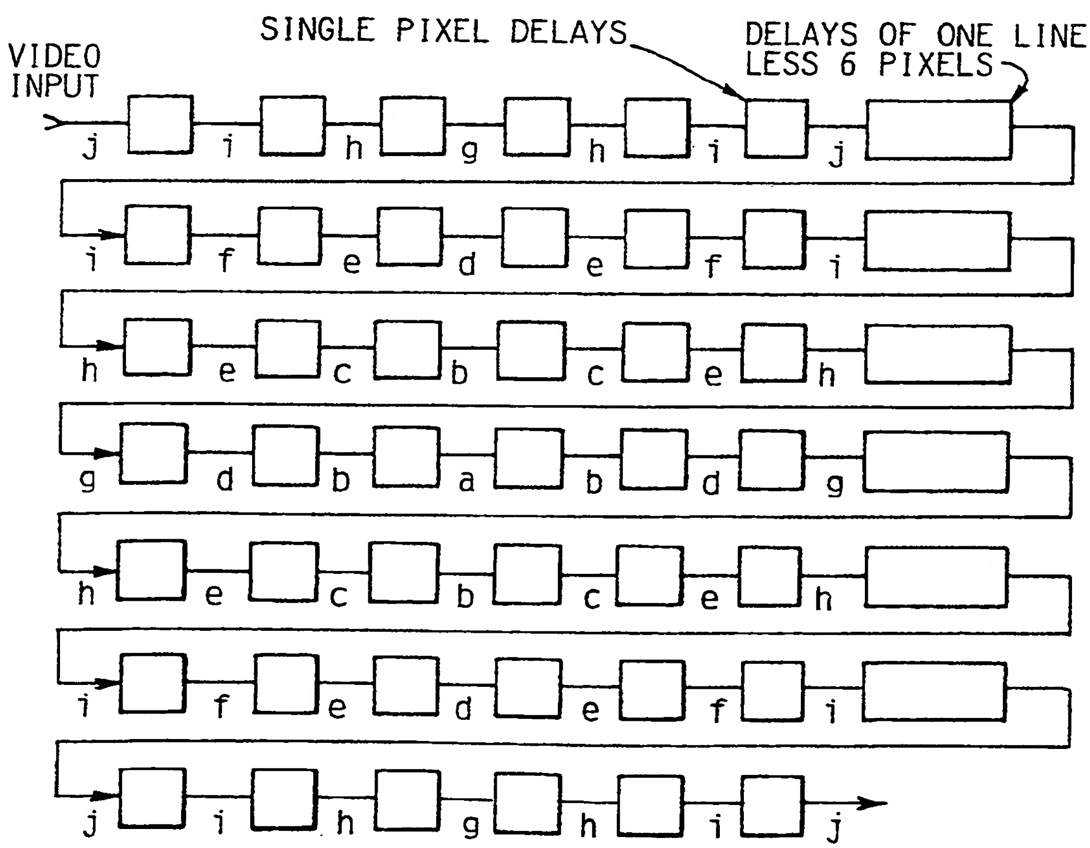

SINGLE PIXEL DELAYS
DELAYS OF ONE LINE LESS 6 PIXELS
VIDEO INPUT
j i h g h i j
i f e d e f i
h e c b c e h
g d b a b d g
h e c b c e h
i f e d e f i
j i h g h i j

FIG. 12

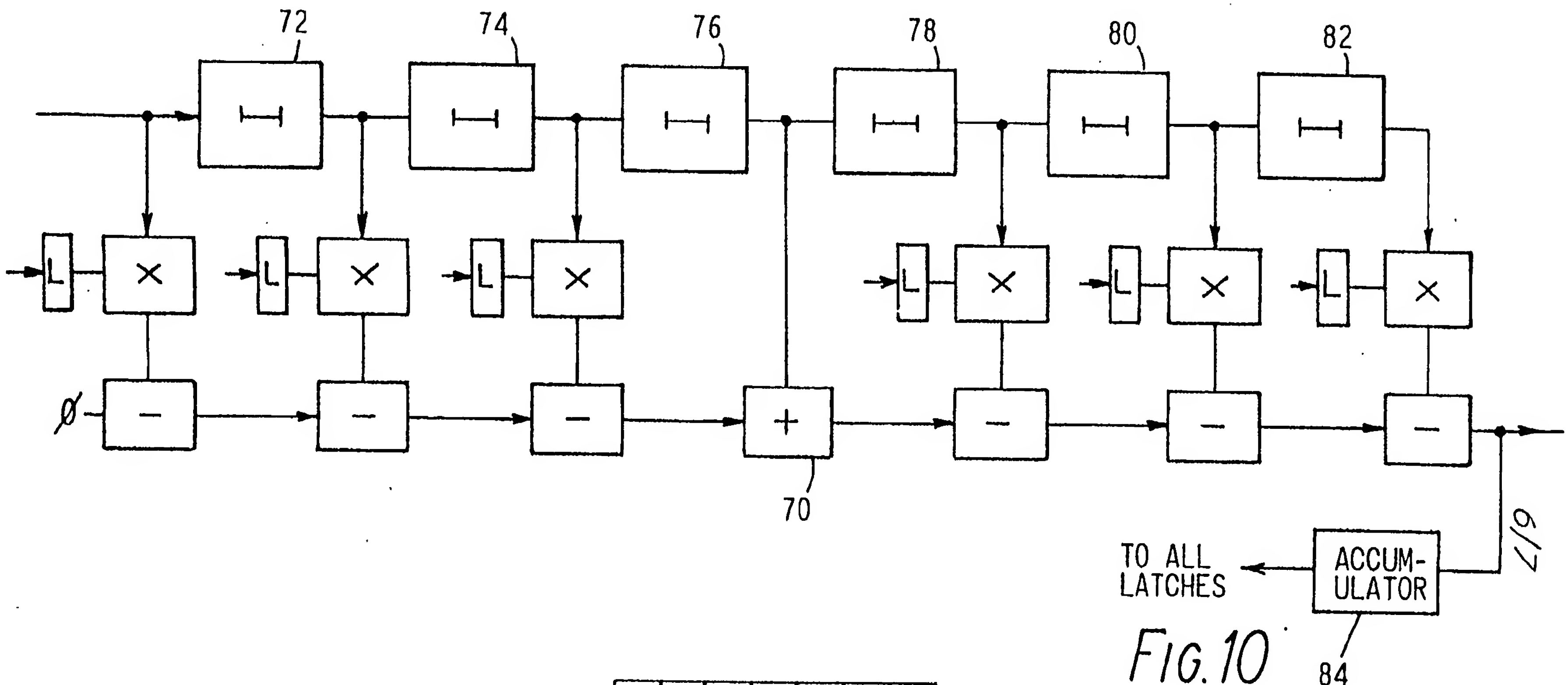



FIG. 10

| | | | | | | |
|---|---|---|---|---|---|---|
| j | i | h | g | h | i | j |
| i | f | e | d | e | f | i |
| h | e | c | b | c | e | h |
| g | d | b | a | b | d | g |
| h | e | c | b | c | e | h |
| i | f | e | d | e | f | i |
| j | i | h | g | h | i | j |

FIG. 11

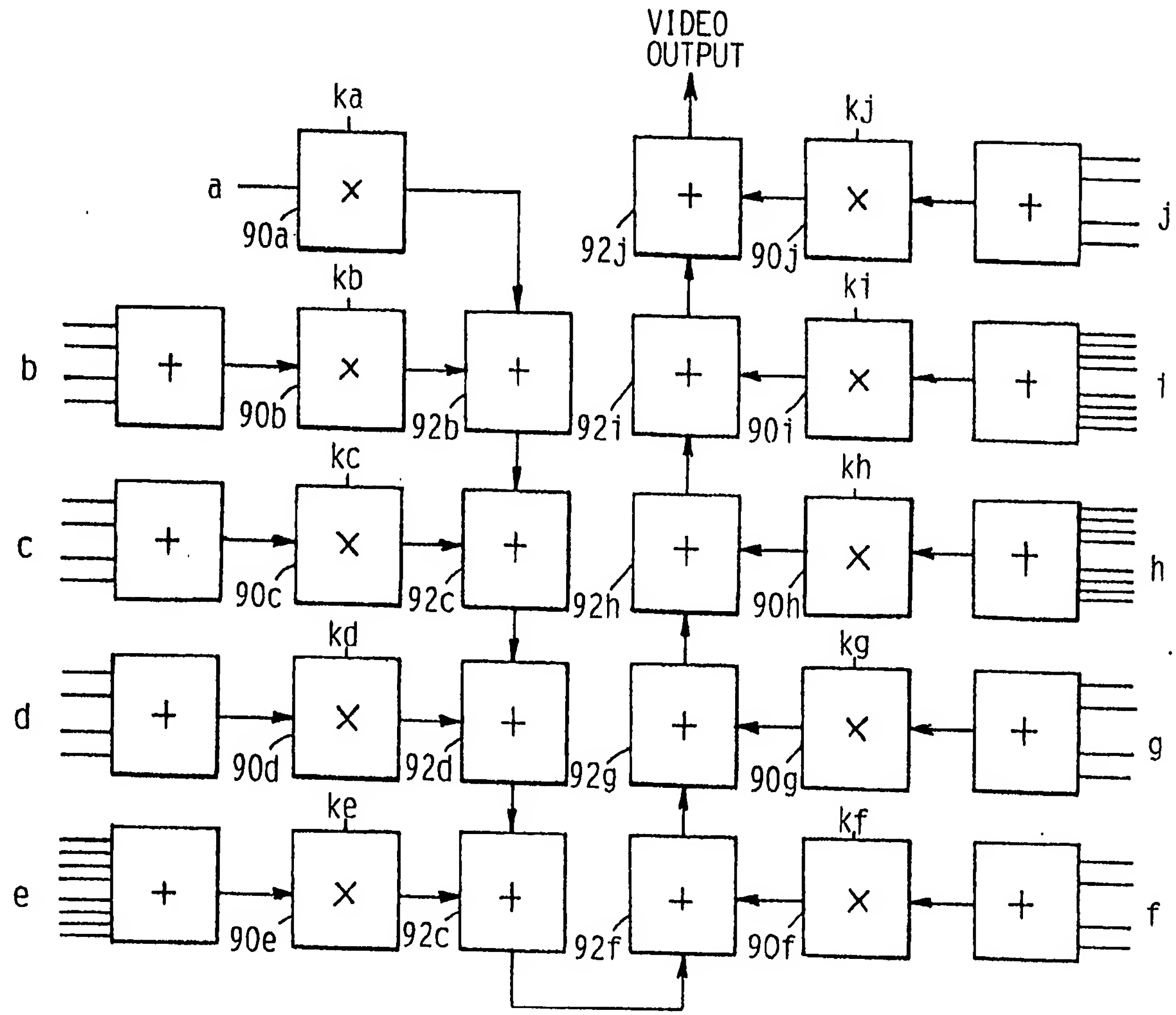

VIDEO OUTPUT
ka
kb
kc
kd
ke
kf
kg
kh
ki
kj
a
b
c
d
e
f
g
h
i
j
90a
90b
90c
90d
90e
90f
90g
90h
90i
90j
92b
92c
92d
92c
92f
92g
92h
92i
92j

FIG. 13

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IMPROVEMENTS IN AND RELATING TO FLYING SPOT SCANNERS

This invention relates to flying spot scanners, and in particular to methods of and apparatus for compensating for deviations from an ideal output signal caused by inherent properties of the flying spot scanner such as afterglow and/or flare.

The invention is particularly applicable to telecine. In essence, flying spot telecine operates by imaging a cathode ray tube raster onto a film, collecting the light passing through the film and converting the collected light into a television signal representative of the images on the film. A problem with such telecines is afterglow, which is the persistence of light from the cathode ray tube phosphor after the spot has moved. When the film changes from clear to dense, the video output should immediately change to a minimum. However, afterglow effects cause a decay from peak to minimum signals. This decay shows itself as a decaying white streak to the right of any white information on a black picture. In existing machines, the afterglow characteristic of the phosphor used decays to 10% in about 150 nanoseconds but continues to emit smaller proportions of light which remain significant for about 50 microseconds.

For a infinitely small clear spot on an otherwise dark film, picture streaking will follow the phosphor decay curve. However, if a larger spot of clear film is considered the streaking will correspond to the integral of the phosphor decay curves over the exposed scan time. To overcome this unwanted streaking it has been common practice to correct for afterglow using a series of individually adjustable differentiating circuits in an analogue corrector circuit.

Previously, the afterglow correcting circuitry has been the only remaining analogue component of a telecine machine. It would be desirable to provide a digital afterglow corrector that was compatible with the remainder of the telecine. However, although the existing analogue correctors could be simulated using equivalent digital circuits, these would be very complex with little direct benefit.

Flare is a phenomenon which is present in all flying spot scanners. Flare may be divided into three broad categories; high frequency flare, low frequency flare and flare ringing at intermediate frequencies. Flare rings are known to be caused by changes of refractive index at the glass/air interface at the face plate. This causes light to be reflected back to the phosphor screen at different positions producing a ring around the spot. Although it is not posssible to say exactly what causes high and low frequency flare it is clear that both types are produced from a number of different sources which interact with one another, for example general background light and local scattering at the glass-to-air interface. This latter type varies with the image position and is much greater at the edge of an image and tends to smear the image. Multiple reflections tend to produce higher frequency flare.

Although flare can be reduced to an extent by using high quality faceplates and by increasing the thickness of the faceplate as described, for example, in our European patent application EP-A-0266154, flare remains a problem.

The invention aims to provide a circuit which can correct a digital video signal for afterglow and/or flare, which is relatively simple, and which is automatic. In its broadest form, the invention provides a corrector circuit which determines the contribution to the video signal at any given

location made by afterglow or flare from adjacent scanning locations and which subtracts this contribution from the video signal. More specifically, the invention provides a method of correcting a digital signal produced by a flying spot scanner to compensate for deviations from an ideal output signal caused by inherent properties of the flying spot scanner, comprising the steps of determining for the signal corresponding to a given location of the flying spot, the contribution to the signal from each of a plurality of adjacent scanning locations or groups of locations, and subtracting each of the determined contributions from the video signal to provide a corrected signal.

In one embodiment, the signal is a video signal and is subjected to a series of delays each equal in length to the time taken for the spot to scan one location or group of locations, and the signal after each of the delays is scaled according to the aggregate length of delay, each of the scaled delayed signals being subtracted from the video signal corresponding to the said given spot location.

Preferably, the scaling of the delayed signals is achieved by applying scaling factors to the signals, which factors are derived by blanking the cathode ray tube at all locations except one and measuring the value of the video signal from that location after each of the series of delays.

In one embodiment, the method corrects afterglow of the phosphor on the CRT face, in which case contributions are determined for scanning locations already visited by the flying spot. In another embodiment the method corrects for flare and the contributions are determined for locations substantially symmetrically arranged about the given location.

In one embodiment, each delay is equal in length to the time taken for the spot to scan one pixel of the cathode ray tube (C.R.T) scanning map. Although accurate, this embodiment would require in the order of 500 stages to compensate for an afterglow which persisted for 30 microseconds. In order to reduce the cost with only a slight loss in accuracy, a further preferred embodiment of the invention increases the length of each delay to twice that of the previous delay. Thus, the length of each delay is equal to $(2^n-1)$ times the time taken to scan one location, where n is the position in the series of the delay relative to the given location (i.e. symmetrically disposed about the central point for flare correction). A compromise between the two may be chosen in which the length of each successive delay increases as the aggregate delay increases.

In one embodiment, flare from adjacent pixels on the same horizontal scanning line only is corrected for. In a modification correction is two-dimensional and is extended to, for example, a 7 x 7 block of pixels including the test pixel.

The invention also provides apparatus for correcting a digital signal produced by a flying spot scanner to compensate for deviations from an ideal output signal caused by inherent properties of the flying spot scanner, comprising means for determining for the signal corresponding to a given flying spot location, the contribution to that signal from each of a plurality of adjacent scanning locations or groups of locations, and means for subtracting each of the determined contributions from the video signal to provide a corrected signal.

The apparatus may comprise means for subjecting the video signal to a series of delays each equal in length to the time

taken for the spot to scan one location or group of locations, and means for scaling the signal after each of the delays according to the aggregate length of delay, the subtracting means comprising means for subtracting each of the scaled delayed signals from the video signal corresponding to the said given spot location.

Similarly to the method of the invention, the apparatus may be used either as a flare corrector or as an afterglow corrector.

The invention further provides apparatus for clamping the black level of an analogue video signal, comprising means for converting the analogue signal into a digital signal, means for correcting the digital signal to compensate for afterglow from a flying spot telecine, and means for determining the black level of the corrected signal, wherein a black level clamp correction signal is formed by black level measurement means and applied to the analogue video signal.

A further aspect of the invention is a method of clamping the black level of an analogue video signal, comprising converting the analogue signal into a digital signal, correcting the digital signal to compensate for afterglow from a flying spot telecine, determining the black level of the corrected signal, deriving a black level clamp correction signal from the determined black level and applying the clamp correction signal to the analogue video signal.

The invention in its various embodiments is particularly suited for use with telecine machines. However, it is also applicable to television cameras and other apparatus using flying spot scanners.

Embodiments of the invention will now be described by way of

example and with reference to the accompanying drawings, in which:

Figures 1a to 1d show respectively the ideal and actual composition of the video signal at any scanning location, the composition of the correcting signal, and the composition of the corrected signal;

Figure 2 is a block diagram of a first embodiment of the invention;

Figure 3 is a schematic representation of a second embodiment of the invention;

Figure 4 is a schematic representation of a circuit section of a third embodiment of the invention;

Figure 5 is a waveform diagram for a single pixel showing corrections made to correct afterglow using the circuit of Figure 2;

Figure 6 is a waveform diagram similar to Figure 5 for a three pixel wide pulse;

Figure 7 is a circuit segment of a fourth embodiment of the invention;

Figure 8 is a block diagram of a black level clamping circuit;

Figure 9 is a schematic diagram illustrating the effects of flare on a pulse;

Figure 10 is a block diagram of a flare correcting circuit embodying the invention;

Figure 11 is a schematic diagram illustrating two-dimensional flare;

Figure 12 shows the video path in a system correcting for two-dimensional flare; and

Figure 13 is a circuit diagram showing how two-dimensional flare can be corrected for.

Ideally, the video signal representing any one scanning location is formed solely from light attributable to the flying spot at that location. Such an ideal response is shown in Figure 1a. However, in practice, the signal contains additional components from previously scanned locations due to afterglow. Thus, the actual video signal is made up of the component from that location, together with a series of additional components from previous scanned locations, the size of the previous components decreasing with increasing time since scanning. This actual composition is shown in figure 1b.

In order to compensate for these additional components, the afterglow correcting circuit to be described attempts to reproduce the additional afterglow components (figure 1(c)) and to subtract these reproduced components from the actual measured video signal. Thus, the corrected signal shown in figure 1(d) should be equal to the ideal signal of figure 1(a).

Figure 2 shows a first embodiment of the automatic afterglow correcting circuit. The circuit employs a plurality of

successive processing elements each incorporating a delay. Three such elements 10, 12, 14 are shown in figure 2. Each processing element represents one pixel of the scanning map and so each delay element 10, 12, 14 is equal to the length of time taken by the flying spot to traverse one scan location; for example 54 nanoseconds. In order to obtain good afterglow correction, a series of elements having a total of about 30 microseconds should desirably be provided although a total delay between 20 and 50 microseconds may be adequate.

In addition to the pixel delay, 10, 12, 14, each processing element comprises a signal multiplier 16, 18, 20 having one input supplied from the delay and the other input provided by a storage element 22, 24, 26, and a subtractor, 28, 30, 32 which subtracts the output of the multiplier from the input video signal Vin. The storage elements are conveniently latches L1 to L3.

Upon switching on or resetting the telecine machine, a set of co-efficients dependent on the response of the phosphor of each pixel of the scanning map is calculated in a process known as alignment. This process is described more fully in our co-pending application GB8913924.0. During the alignment process, the storage elements 22, 24 and 26 are loaded with appropriate co-efficients proportional to the level of decay of the phosphor after the aggregate delay at that stage. Thus, if there are n circuit elements and the elemental delay is assumed to be 54 nanoseconds, storage element 26 will be loaded with a co-efficient representing the decay after n x 54 nanoseconds and storage element 24 will be loaded with a co-efficient representing the decay after (n-1) x 54 nanoseconds etc.

Additional delays are added to the measured decay values to

compensate for the pipeline delays of some components. To determine the decay values, the C.R.T. is blanked during the alignment operation at all locations but for one pixel. The value of the video output from that pixel occurring after each pixel delay is stored. To avoid the effects of random noise the alignment will perform many (for example 32) measurements of the decay values using the averages of these measurements as the stored co-efficient values.

Thus, at the end of each stage the product of the stored co-efficient representing the level of decay of light from previous scan locations and the video signal from that location is subtracted from the undelayed video signal. The output of each subtractor 28, 30, 32 is a signal from which has been removed afterglow from one further scan location. The cumulative effect of all the stages is to remove the effects of afterglow for substantially all of the decay period of the phosphor.

In figure 2 an accumulator 33 is included at the output of the final subtractor 32. The output of the accumulator 33 provides the input for the latch 22, 24, 26 of each stage. It is to be realised that the accumulator 33 is not essential.

Operation of the embodiment of Figure 2 will now be described with reference to Figures 5 and 6 which show, respectively, waveform diagrams for a single pixel width pulse such as is used during alignment and a wider pulse; in this example three pixels wide.

The ideal signal is shown for each pulse and it is desired that the corrected output should correspond as closely as possible to the ideal signal.

The description is given, for simplicity, for the three stage example and, in this case, the corrected output will not be ideal and the corrected waveforms will not conform to those shown in Figures 6 and 7E to the right of dotted line 52. The residual errors that are present are corrected by using further stages as mentioned previously.

Alignment is described with reference to figures 2 and 5, and is commenced by setting up scan blanking such that a single pixel only is illuminated. This pixel should be near the picture centre. Latches 22, 24 and 26 are set to zero and the accumulator is cleared.

When time interval 2 is at the output, input value a) (Figure 7A) is stored in the accumulator 33. This is repeated for a further 31 frames and the accumulator sum is divided by 32. This value is loaded into latch 22. The output is now corrected by latch 22.

Thus the output of the corrector is as follows:

| Time interval | Output |
|---|---|
| 1 | 1 |
| 2 | a-(1 x a) = 0 |
| 3 | b-(a x a) = $b-a^2$ |

The accumulator is then cleared and, when time interval 3 is at the output, the process decribed above is repeated and the value $(b-a^2)$ is loaded into latch 24 (the second stage latch). Thus the corrector output is now:

| Time Interval | Output |
|---|---|
| 1 | 1 |
| 2 | $a-(1 \times a) = 0$ |
| 3 | $b-(a \times a) - 1(b-a^2) = 0$ |
| 4 | $c-(b \times a) - a(b-a^2) = c-2ab+a^3$ |

This output has been corrected by latches 22 and 24.

The accumulator is then cleared again and when time interval 4 is at the output the averaged value $c-2ab+a^3$ is loaded into the third stage latch 26. Thus the output now becomes:

| Time Interval | Output |
|---|---|
| 1 | 1 |
| 2 | $a-(1 \times a) = 0$ |
| 3 | $b-(a \times a)-1(b-a^2) = 0$ |
| 4 | $c-(b \times a)-a(b-a^2)-1(c-2ab+a^3) = 0$ |

Thus the output is corrected by the three latches 22, 24 and 26 and the output E in Figures 5 and 6 is $A-B(a)-C(b-a^2)-D(c-2ab+a^3)$.

The alignment blanking is then switched off and the machine returned to normal operation in which the outputs are automatically corrected. Of course, in practice there would be very many more stages in the correction process.

The addition of the accumulator averaging over 32 samples has the advantage of preventing errors caused by noise. Any number of samples may be taken and 32 is only given as an example.

Although the circuits described are accurate and provide improved performance, they require in the order of 500 processing elements in order to achieve a 30 microsecond compensation. Such a circuit may be uneconomical to produce. An alternative embodiment of figure 3 takes into account the fact that the contribution to the overall afterglow decreases with increasing delay. In figure 3, the signal delay is increased by a factor of 2 in each processing section. Thus, the first stage has a delay of one pixel, the second has a delay of two pixels, the third four pixels and so on. The delay at any stage is $2^{n-1}$ pixels where n is the number of the stage in the series.

The embodiment of figure 3 can achieve the required 500 pixel delay using only nine stages. These nine stages have a total of $2^9-1 = 511$ pixels which, at 54 nanoseconds per pixel represents a total delay of 27.6 microseconds. This embodiment reduces the complexity and cost of the circuit greatly whilst being accompanied by only a slight reduction in accuracy. A compromise between the circuits of figures 2 and 3 may be chosen.

Where the stages of the corrector have different delay times; it is necessary to include an accumulator stage at the input of each multiplier. This modification is shown for a single stage in Figure 4. An accumulator 50 is interposed between the delay stage and the multiplier. The accumulator 50 sums all the video samples during the preceding delay period. The total is then applied to the multiplier for correction by the contents of the latch and the accumulator is reset for the next delay period.

During the alignment sequence the latch is loaded with the average output value of the pixel occurring in the centre of

that preceding delay period but otherwise using the alignment sequence previously described with reference to Figure 2.

A further modification is illustrated in Figure 7. The latches of the previous embodiment are replaced by a combination counter/latch 60 which is connected to the output of a comparator 62. The inputs of the comparator are the output of the multiplier, for example multiplier 18, and the blanking level.

In this figure only a single circuit section is shown although a number of sections would be used as in the previous embodiment. The circuit is shown with an accumulator stage as it is a modification for the figure 4 circuit although this accumulator is not used during alignment and is inessential.

The circuit operates in the following manner. The counter/latch is cleared to zero, and a test film fitted or alignment scan blanking activated. At the appropriately timed pixel the comparator 62 compares the output of multiplier 18 with its ideal value (blanking level), and increments or decrements the counter so as to improve the result. This process is repeated iteratively, but substantially simultaneously (in practice in quick sequence) for each circuit section. Where the counter 60 is a 16 bit counter, $2^{16}$ interations may be required to achieve the correct value with the addition of a further few for noise averaging. However since the comparison is done on a proportional basis, the effects of line to line shading are no longer important, therefore the interations can be repeated at line rate.

A further problem which arises from the use of digital afterglow correction is that clamping of the signal black level cannot be done until after afterglow correction.

However, black level clamping is required before A-to-D conversion of the input signal prior to correction.

This problem may be overcome by the circuit of figure 8 in which the input analogue signal is converted to a digital signal by A-to-D converter 34. The digital signal is then corrected to remove afterglow by corrector 36 which may be of any of the types illustrated and the corrected signal taken as the output. The corrected signal also forms the input to a black level measurement device 38, the output of which is a clamp correction signal. This signal is fed back to the analogue circuits preceding the A-to-D converter 34. In figure 9 these circuits are represented by input amplifier 40.

The invention in its various embodiments has been described in relation to afterglow measurement and compensation. However, it is equally applicable to optical flare correction. the situations in which flare arises and the nature of flare has already been discussed. Figure 9 shows how flare may affect a square pulse. The desired signal shape is referenced with the number 90. High frequency flare causes the transition from low to high to become less than instantaneous - illustrated at 92; flare ringing causes the characteristic peak 94 at a distance away from the pulse and low frequency flare 96 ensures that the pulse never reaches the low (black) level due to background light.

Figure 9 illustrates the complexities of flare which make it difficult to correct for. In the embodiment of Figure 10, the automatic alignment sequence is utilised to store the flare profile with an accuracy dependent upon the number of samples used and the time interval between those samples. Because of the possible discontinuities such as the flare ring 94, it may be desirable to choose the samples and time intervals to

optimise performance on individual systems. Figure 10 illustrates a circuit which operates in a similar manner to that of figure 2 but allows for the fact that flare is a problem which affects pixels on both sides of the pixel being corrected whereas afterglow only affects those pixels which have already been visited by the flying spot. Thus, in the embodiment of Figure 10 three circuit sections are arranged on either side of the main signal point. On the left hand side of adder 70 there are three delay elements 72, 74, 76 and three delay elements 78, 80, 82 to the right of the adder.

It is to be understood that the output of the accumulator 84 is connected to the inputs of all the latches.

The operation of the flare correction unit is slightly different due to the differences in the natures of flare and afterglow. Whereas afterglow is a temporal effect, flare is spatial in nature. Thus, instead of using a single illuminated pixel for alignment, the whole raster is illuminated and a test slide or a film with a pixel sized clear spot on an otherwise opaque film is used. From thereon the process is very similar to that described with reference to Figure 2 for the circuits corresponding to delay elements 78, 80, 82, the correction co-efficients being copied into the symmetrically disposed latches corresponding to delay elements 72, 74, 76. Necessary modifications are made for the additional pipeline delays. This will be readily understood by those skilled in the art and need not be discussed further.

It will be appreciated that the circuits of Figures 4 and 7 may also be adapated for use as flare correctors and, as the principles are the same as the modifications necessary to arrive at the circuit of Figure 10, detailed description is not necessary. The figure 4 embodiment is realised by

omitting accumulator 84 and adding an accumulator between each delay and multiplier, except in the case of the centre point where no accumulator is necessary and the leftmost multiplier where the input is undelayed but an accumulator is required.

The figure 7 embodiment is realised by replacing each latch with a comparator and a latch/counter as described with respect of that figure.

Due to the symmetrical nature of flare the flare correctors described in their various embodiments can be modified by combining pairs of latches, thus reducing cost.

The circuits described enable a CRT display to be corrected for either afterglow or flare. It is possible to operate the circuit of figure 10 such that it corrects for both flare and afterglow.

Alignment by blanking the CRT beam results in a set of co-efficients which essentially describe the afterglow profile, whereas alignment by use of a film or blanking plate in the film path result in a set of correction co-efficients which describe a combination of afterglow and flare. Video data preceding the pulse is only affected by flare whereas data following the pulse is affected by both flare and afterglow.

The circuit of figure 10 can be aligned using film blanking to achieve a combined correction by measuring video levels at the appropriate times before and after the pulse, and then to calculate the correction co-efficients according to the formula derived for the afterglow correction circuit; $A-B(a)-C(b-a^2)-D(c-2ab+a^3)$.

An alternative method is to align succeeding samples after the pulse using CRT beam blanking according to the method described with reference to the operation of the circuit of figure 2 and to store the resultant values. This process is then repeated but using film blanking. The values obtained using film blanking are used as the correction co-efficients for succeeding samples. Correction co-efficients for the symmetrically disposed preceding samples are derived by subtracting from the stored 'beam blanking' coefficients from the 'film blanking' coefficients.

The flare correction circuitry described only corrects for video distortion occurring in the horizontal scanning direction.

Flare causes video distortions which are essentially symmetrical in two dimensions, full correction would therefore also require a vertical component of correction. The vertical correction may be accomplished by the same means as described previously but the delay elements would be of integral line times. By operating the vertical and horizontal correction in tandem a simple approximation to two-dimensional correction may be achieved.

Figures 11 to 13 illustrate how a more accurate method of providing two-dimensional flare correction is achieved.

Figure 11 shows how flare surrounds a single illuminated pixel (marked 'a'). Each square represents one pixel of the scanning map, only 7 x 7 pixels of the scan are shown. The other letters indicate the relative amount of flare at each location.

A full correction over this 7 x 7 area would need 49 circuit

blocks. However the circuitry can be simplified to 9 flare correction blocks by taking advantage of the symmetry. Figure 13 shows a schematic diagram which could be used to correct this 7 x 7 area. The circuit operates as a logical extension of figure 10. Alignment would preferably be performed by measuring the signal at a selection of delay points and from these calculating suitable correction co-efficients.

Figure 12 shows the video path for a signal at pixel a which includes pixel delays at each of the points from which there is a flare contribution and line delays between adjacent lines.

Considering figure 13 in more detail it will be appreciated that each of the flare derivation circuits a to j have a number of inputs equal to the number of pixels in the 7-by-7 matrix which have that degree of flare. Thus, there is a single input from the 'a' flare corrector but eight inputs from the 'e' corrector. Each of the circuits is similar to that illustrated in Figure 10. The output from each corrector is passed to a respective multiplier 90a to 90j and multiplied with a respective flare co-efficient 12ka to 12kj. The co-efficient is indicative of the relative strength of the flare at each of the points a to j. Thus 12a is the largest co-efficient. In addition the co-efficients are scaled to take account of the number of inputs to the respective multipliers. Thus, 12d includes a quarter scaling factor with respect to 12a. The output of multiplier 90a forms the input to an adder 92b which receives as its other input the output of multiplier 90b. The output from this adder forms the input to adder 92c and so on until the output of 92j represents the video signal corrected for two-dimensional flare.

The circuit of figure 10 may be considered as an F.I.R. filter

with provision for adjusting the filter co-efficients according to signal measurements, and similarly figure 13 can be considered as a two dimensional F.I.R. filter.

Once the flare of a given system is known and remains constant, the alignment process could be dispensed with and the latches loaded with a set of predetermined coefficients.

The flare and afterflow correcting circuits provide a profile of the CRT flare and afterglow respectively. These profiles can be used as measurement methods in CRT research, for example in assessing the performance of CRT phosphors.

Although the description has been given with reference to a hardware system, it will be appreciated that the correction circuit could largely be implemented in software, in which case the various circuit diagrams of the figures may be regarded as being in the nature of flow charts.

## CLAIMS

1. A method of correcting a digital signal produced by a flying spot scanner to compensate for deviations from an ideal output signal caused by inherent properties of the flying spot scanner, comprising the steps of determining for the signal corresponding to a given location of the flying spot, the contribution to the signal from each of a plurality of adjacent scanning locations or groups of locations, and subtracting each of the determined contributions from the signal to provide a corrected signal.

2. A method according to claim 1, wherein the signal is subjected to a series of delays each equal in length to the time taken for the spot to scan one location or group of locations, and the signal after each of the delays is scaled according to the aggregate length of delay, each of the scaled delayed signals being subtracted from the digital signal corresponding to the said given spot location.

3. A method according to claim 2, wherein the scaling of delayed signals is derived by illuminating the cathode ray tube face at a single scan location or group of locations and measuring the value of the digital signal from that location after each of the series of delays.

4. A method according to claim 3, wherein illumination of a single location or group of locations is achieved by blanking the CRT beam at all other locations or groups of locations.

5. A method according to claim 2, wherein the scaling of the delayed signals is derived by illuminating the cathode ray tube raster and inserting an opaque test slide or film having

a clear spot the size of the location or group of locations.

6 . A method according to claim 3, 4 or 5 wherein the scaling of delayed signals is derived from the average of a plurality of measurements of the value of the video signal from the said location after each of the series of delays.

7. A method according to any of claims 1, to 6 wherein each of the delays is equal in length.

8. A method according to claim 7, wherein each delay is equal to the time taken to scan one pixel of the cathode ray tube.

9. A method according to any one of claims 1 to 6, wherein the length of each successive delay increases as the aggregate length of delay increases.

10. A method according to claim 9, wherein the length of each delay is equal to $(2^n-1)$ times the time taken to scan one location, where n is the number in the series of the delay.

11. A method according to any preceding claim, wherein the total delay time of the series of the delays is in the range 20 to 50 microseconds.

12. A method according to any preceding claim, wherein the deviations corrected for are caused by afterglow and the signal corrected for is a video signal, and the adjacent scanning locations or groups of locations for which a contribution is determined are locations or groups of locations previously visited by the flying spot.

13. A method according to any of claims 1 to 11, wherein the deviations corrected for are caused by flare and the adjacent

scanning locations or groups of locations for which a contribution is determined are substantially symmetrically arranged around the flying spot at the said given location.

14. A method according to claim 12 or 13 wherein the locations or groups of locations for which a contribution is determined are on the same scanning line.

15. A method according to claim 13, wherein the flare correction is two-dimensional and the locations or groups of locations for which a contribution is determined are on a plurality of adjacent scanning lines.

16. A method of correcting a digital signal produced by a flying spot scanner to compensate for afterglow and flare, comprising the steps of determining the afterglow contribution to the signal according to the method of claim 4 to acquire a first set of determined contributions and storing the first set, determining the flare contribution to the signal according to the method of claim 5 to acquire a second set of determined contributions, subtracting the second set of contributions from the locations or groups of locations succeeding the given location, subtracting the first set of contributions from the second set of contributions to form a third set and subtracting the third set from the locations or groups of locations preceding the given location.

17. A method according to claim 6, wherein the contribution for each scanning location or group of locations is derived by an individual circuit section having means for holding a scaling factor, comprising the steps of:

a) clearing the holding means of each circuit section;

b) at a time (t+a), measuring the contribution at a first scan location or group of locations over a plurality of scan frames, where t is the time at which the said given location is scanned and a is the time taken to scan a single location or group of locations or a multiple thereof;

c) holding each contribution in an accumulator, taking the average and loading the average into the holding means of the holding means corresponding to the first scan location or group of of locations;

d) clearing the accumulator;

e) repeating steps b) to d) at time (t+2a) for the second scan location;

f) repeating step e) for each subsequent scan location or group of locations until (t+na) where n is equal to the total number of circuit sections; and

g) applying the contents of each holding means to the signal to correct the signal.

18. A method of operating a flying spot scanner comprising deriving a set of contributions according to the method of any previous claim, storing the contributions and automatically applying the contributions to a signal on subsequent operation of the scanner.

19. A method of clamping the black level of an analogue video signal, comprising converting the analogue video signal into a digital signal, applying the method of any preceding claim to the digital signal, measuring the black level of the corrected signal and applying a clamp correction signal derived from the

black level measurement to the analogue video signal prior to conversion.

20. Apparatus for correcting a digital signal produced by a flying spot scanner to compensate for deviations from an ideal signal caused by inherent properties of the flying spot scanner, comprising means for determining for the signal corresponding to a given flying spot location, the contribution to that signal from each of a plurality of adjacent scanning locations or groups of locations, and means for subtracting each of the determined contributions from the video signal to provide a corrected signal.

21. Apparatus according to claim 20, comprising means for subjecting the signal to a series of delays each equal in length to the time taken for the spot to scan one location or group of locations, and means for scaling the signal after each delay according to the aggregate delay length, the subtracting means including means for subtracting the scaled delayed signals from the video signal corresponding to the said given spot location.

22. Apparatus according to claim 21, comprising means for deriving scaling factors for application by said scaling means, comprising means for illuminating a single scan location or group of locations of the cathode ray tube, and means for measuring the video signal from the unblanked location after each of the series of delays.

23. Apparatus according to claim 13, wherein the deriving means comprises accumulator means for storing and taking the average of a plurality of measurements of the signal from the illuminated location after each of the series of delays.

24. Apparatus according to claim 23, wherein an individual accumulator is associated with each delay in the series.

25. Apparatus according to claim 23, wherein a single accumulator means successively stores and takes the average of the signal after each of the series of delays.

26. Apparatus according to any of claims 20 to 25, wherein each delay is of equal length.

27. Apparatus according to claim 26, wherein each delay is selected to be equal to the time taken to scan one pixel of the cathode ray tube.

28. Apparatus according to any of claims 20 to 25, wherein the length of each successive delay increases as the aggregate length of delay increases.

29. Apparatus according to claim 28, wherein the length of each delay is selected to be equal to $(2^n-1)$ times the time taken to scan one location, where n is the position in the series of the delay.

30. Apparatus according to any of claims 20 to 29, wherein the apparatus corrects for afterglow of the CRT phosphor and the determining means determines contributions for a plurality of locations or groups of locations already visited by the flying spot.

31. Apparatus according to any of claims 20 to 29, wherein the apparatus corrects for flare and the determining means determine contributions for a plurality of locations or groups of locations substantially symmetrically arranged around the said given location.

32. Apparatus according to claim 31, comprising a plurality of flare correcting circuits for correcting flare on a plurality of scanning lines adjacent to the given location. Each circuit correcting one or more scanning locations having a substantially identical flare intensity.

33. Apparatus according to any of claims 30, 31 or 32, comprising an individual circuit section for deriving the contribution for each scanning location or group of locations.

34. Apparatus according to claim 33 wherein the holding means for each circuit section comprises a latch.

35. Apparatus according to claim 33 wherein the holding means comprises a counter and a latch, the input to the counter and latch being the output of a comparator arranged to compare the blanking level with the output of the circuit section.

36. Apparatus for clamping the black level of an analogue video signal, comprising means for converting the analogue signal into a digital signal, means according to any of claims 20 to 33 for correcting the digital signal for afterglow and/or flare, and means for determining the black level of the corrected digital signal, whereby a black level clamp correction signal is formed from the output of the black level measurement means and applied to the analogue video signal.

37. Apparatus for clamping the black level of an analogue video signal, comprising means for converting the analogue signal into a digital signal, means for correcting the digital signal to compensate for flare and/or afterglow from a flying spot telecine; and means for detemining the black level of the corrected signal, wherein a black level clamp correction

signal is formed by black level measurement means and applied to the analogue video signal.

38. A method of clamping the black level of an analogue video signal, comprising converting the analogue signal into a digital signal, correcting the digital signal to compensate for flare and/or afterglow from a flying spot telecine, determining the black level of the corrected signal, deriving a black level clamp correction signal from determined black level and applying the clamp correction signal to the analogue video signal.



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